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A spectralanalytic approach to emotional responses evoked through picture presentation

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ABSTRACT

Frontal EEG asymmetry has been linked to emotional and motivational reactivity. A frequently applied method to provoke specific asymmetry profiles is the presentation of affective film clips. Although these films might elicit strong emotional reactions, the exact time course and peak of an affective response remains unclear. In an alternative attempt, stimuli from the *International Affective Picture System (IAPS)*, known to reliably alter emotional states, are utilized. These stimuli are less likely to cause excessive variations in affective responding. However, relevant studies have most often been unable to find the predicted effects. One reason for such failures might be the inadequate knowledge about the minimum number of stimuli needed for psychometrically stable results. In the present study, an adequate split-half reliability for the experimental procedure was assured and substantial effects of affective picture category were found. This pattern of results was robust for both Cz and linked ears as reference. Thus, presenting pictures with an adequate recording length might be a reliable alternative for inducing affective reactions in alpha asymmetry research.

1. Introduction

In recent years much research has been devoted to the understanding of the biological systems mediating the motivational components of emotional responding. In this context, two core dimensions of behavioral relevance, approach and avoidance, have extensively been studied using emotional film clips to alter the participants' affective states and motivated behavior. By means of electroencephalographic investigations functional asymmetries have been observed indicating a greater relative left frontal activity associated with approach motivation and greater relative right frontal activity associated with withdrawal motivation (e.g. Davidson, 2004; Coan and Allen, 2004). Most often these studies infer the degree of cortical activation from the power in the alpha band (8–12 Hz) at several electrodes, with lower values in the alpha range indicating a higher degree of activity. Not surprisingly, such findings of functional asymmetries have increased the interest in the lateralization of motivational states and traits. Studies with both healthy subjects (e.g. Jackson et al., 2003) and patients with emotional disorders (Allen et al., in press) support the notion that left and right frontal regions are involved in approach- and withdrawal-related affect, respectively. However, past research did not always produce the predicted results (for reviews, see Murphy et al., 2003; Pizzagalli et al., 2003).

One factor that might have added to such inconsistencies is the fact that the distinct characteristics of film clips with the duration of about 60 s or more are hardly accessible and will not stay constant during presentation. Although these clips might elicit relatively strong emotional reactions, it is unclear when exactly an affective responding occurs or whether the characteristics of the stimulus are stable across time. Collecting data throughout the entire film period might therefore not necessarily be appropriate to find associations between an experimental condition and concurrent cortical asymmetries reflecting emotional responses.

An alternative approach is the use of pictures with known stimulus characteristics. Although pictures do not elicit as strong emotional responses as film clips, it is less likely that excessive variations of affective responding during their presentation will occur. Furthermore, stimuli of the *International Affective Picture System* (IAPS; Lang et al., 2001) are established and reliable elicitors of emotional experiences thoroughly tested in numerous studies using startle methodology (e.g. Schupp et al., 2004). In a recent survey, Gable and Harmon-Jones (2008) found an association of individual differences in the asymmetry of frontal activations to neutral and dessert pictures with the desire for a dessert on the one and the time since the last dessert on the other hand. Despite this successful approach of late, several prior studies, which were presented at international

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conferences (e.g. Elgavish et al., 2003), failed to reliably associate frontal asymmetries with emotional states induced by affective pictures.

Such divergent findings are likely linked to psychometrical characteristics of a given procedure, most importantly the reliability of EEG measures which usually increases as a function of the total recording length. Several studies showed at least good internal consistency (Cronbach's alpha of about 0.80 and above) with resting EEG recorded for 4 min or more (Reid et al., 1998; Hagemann et al., 1998). However, although a variety of studies assessed cortical asymmetries during experimental manipulations via film clips to alter emotional or motivational responding, to our knowledge the reliability of these EEG recordings has not yet been evaluated. Prior studies (e.g. Zinser et al., 1999; Davidson et al., 1990) required as few as 10 to 15 s of artefact free data as a minimum criterion. Given the above mentioned findings with respect to the internal consistency of baseline EEG, longer intervals seem desirable.

Another relevant factor in the interpretation of EEG data concerns the choice of an appropriate reference electrode, which holds especially true for all kinds of topographical analyses. The effects of different reference schemes on measurements of frontal trait asymmetry have been in the focus of evaluation before (Hagemann et al., 1998, 2001; Reid et al., 1998). Critically, measurements against the most often used mathematically linked ears/mastoids and common vertex references did not show strong associations. This lack of convergent validity was not attributable to poor reliability. Most likely, such difficulties have added to the inconsistencies regarding the empirical patterns of relationships between cortical asymmetries and motivational and emotional variables. Therefore, results comparing multiple reference montages should be reported (Allen et al., 2004).

Consequently, this study was meant to test the suitability of the picture presentation paradigm for research on alpha asymmetries measured via EEG. We consider this paradigm to be an alternative to the presentation of film clips loaded with the above mentioned methodological obstacles. By comparing positive and negative stimuli taken from the IAPS and, for now, omitting the otherwise advantageous neutral category, we hoped to maximize differences in cortical responding to the affective pictures. It was expected that the asymmetry metric would indicate a relative right hemispheric activation for negative pictures and vice versa. Models assuming a hemispheric specialization of frontal systems in the mediation of motivational and/or emotional tendencies received empirical support over the last two decades (see special issue of Biological Psychology 1, 2004). Therefore, we expected an effect of the picture condition to be most pronounced at frontal electrode sites. Furthermore, we were interested in the differential effects of reference montages on the evoked cortical asymmetries. We compared the most widely used mathematically linked ears (A1A2) and vertex (Cz) references by including them as repeated measures factor in the statistical analysis. Additionally, reliability measures of the asymmetry metric and activations at single electrode sites were analyzed.

2. Methods

2.1. Design and procedure

Data were collected from 28 right-handed female and male students. The protocol was approved by the Ethical Committee of the University of Münster. Participants gave their informed consent. Participants were screened for symptoms of neurological or psychiatric disorders that could have interfered with the purpose of this study. Handedness was validated using the Edingburgh Handedness Inventory (Oldfield, 1971).

After parameterization of the physiological data including artifact detection and exclusion, the final sample consisted of 16 participants (13 female, 3 male) for statistical analysis. The high exclusion rate of subjects resulted from our rather conservative criterion regarding the minimum of required epochs for averaging (compare section parametrization).

During the experimental session participants were shown a total of 36 photographs from the IAPS (Lang et al., 2001) with positive and negative emotional and motivational content. We selected pictures with high values of arousal, half of them rated as highly positive, the other half as highly negative in valence. The two categories have carefully been matched regarding the arousal ratings and the magnitude of the valence ratings. The final compilation consisted of these pictures: 1300, 3000, 3060, 3102, 3150, 3170, 3180, 3530, 6212, 6230, 6313, 6560, 6570, 7380, 9140, 9570, 9910, 9921, 1710, 4599, 4641, 4660, 5480, 5621, 5700, 5190, 7270, 8030, 8080, 8190, 8200, 8210, 8370, 8380, 8420 and 8470.

The pictures were presented in a restricted randomized order. To maximize the participants' emotional reactivity, three pictures from the same affective category were always presented in succession. Apart from this restriction, the assignment of stimuli of one affective category to these short blocks (three pictures each) and the sequence of such blocks (each single block containing positive or negative pictures only) were random. An interstimulus interval of 2500 ms separated pictures within a block of 3 stimuli having the same valence. This interval consisted of a fixation cross, shown for 1000 ms, preceded and followed by blank screens lasting for 1000 ms and 500 ms, respectively. Transitions from one affective block to the next consisted of a similar sequence of events, but with an extended duration of the first blank screen summing up to an average interstimulus interval of 6000 ms.

Having viewed the stimulus material while EEG activity was recorded concurrently, participants were exposed to the pictures again and had to rate their emotional responses to the stimuli. Ratings were obtained with the Self Assessment Manikin (SAM, Bradley and Lang, 1994) to measure self-report pleasure and arousal. The SAM depicts each dimension with graphic characters along a nine point scale. For pleasure, the endpoints indicate positive and negative affect (low and high scores respectively). Strong arousal is indicated by higher values on the scale. We deliberately refrained from letting the pictures being rated immediately after their presentation during the recording of EEG activity. On the one hand, higher associations between physiological measures and picture ratings might be obtained with shorter intervals between these tasks. On the other hand, intermingling ratings and presentations during the recording of physiological activation would have interfered with our primary affective task.

2.2. Parametrization and statistical analysis

Brain activity was recorded from 28 positions according to the 10-10 System using sintered Ag/AgCl electrodes mounted on a flexible lycra-electrocap (SynAmps amplifier, Compumedics Neuroscan, USA; easycap, Falk Minow Services, Germany). Cz was used as online reference and a ground electrode was placed on the forehead. Two electrode-clips at the earlobes served for later rereferencing of the data to mathematically linked ears. Additional electrodes recorded the bipolar horizontal and vertical electrooculogram (EOG). Impedances were below 5 kΩ and matched for homologous sites with a maximum deviation of 500 Ω. Data were collected at a sampling rate of 500 Hz with filters set to 0.05 and 70 Hz. Epochs with a length of 1024 data points and an overlap of 50% were extracted resulting in a total of 90 segments per category. All segments with artifacts (including those from ocular and muscular sources) were rejected. If less than 50 epochs remained in any of the categories the participant was excluded from further analysis. Epochs were then extracted through a Hanning-window (10%). A Fast-Fourier-Transformation (FFT) was performed to derive estimates of spectral power in the alpha-band (8–13 Hz)